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Section 2 **Test methodology and assessment**

Measurement of wood decay by dynamic MOE in an accelerated soil contact test

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MEASUREMENT OF WOOD DECAY BY DYNAMIC MOE IN AN ACCELERATED SOIL CONTACT TEST

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ABSTRACT

Current laboratory and field testing of preservatives involves various techniques to determine the extent of fungal attack, including visual inspection, mass loss, and static bending and compression strength measurements. The objective of this study was to compare decay measurement by conventional compression strength versus dynamic MOE, employing small wood stakes in an accelerated laboratory soil-contact wood decay test. The maximum decay was generally observed close to the center of the stake. An average correlation of 0.884 was observed between the average compression and dynamic MOE strength losses.

Keywords: accelerated testing, compression strength, decay, dynamic MOE strength, soil, wood preservative

INTRODUCTION

Field stake and soil contact tests are widely used to evaluate the efficacy of the wood preservatives. Currently the extent of decay in lab and field trials is generally determined by use of mass loss, visual inspection, and static bending and compression properties. Another approach using a dynamic MOE method was introduced as a possible method for evaluating the extent of decay in wood durability tests (Machek 1998, Machek 2004, Grinda 2005). These researches found that the decrease in MOE by this method was highly correlated to the degradation of wood by fungi. The dynamic MOE method is attractive because it allows the use of larger wood samples. Although the dynamic method is promising, additional research is needed to address the following questions and concerns:

1. The location of the defects in a given sample could cause significantly different MOE readings (Machek 1998). However, Machek only demonstrated that the location could cause different MOE reading, but did not show how different they are and how to compensate for the difference.
2. The equation for the calculation of the dynamic MOE used by Machek needs to be adapted for samples with larger dimensions, such as those used for field state tests (Grinda 2005).
3. Dynamic MOE needs to be adapted in according with the moisture content (MC) of the samples when it is below the fiber saturation point (Grinda 2005).

4. The possible influence of different forms of attack by the mirco-organisms needs to be investigated (Grinda 2005).
5. More information is needed to compare decay measurement by conventional strength measurements and dynamic MOE.

This study was designed to address the last issue by comparing the extent of wood decay in an un-sterile soil test by both Dynamic MOE and compression strength loss methods.

EXPERIMENTAL METHODS

Wood Samples

The test samples were cut from low density, defect free southern yellow pine sapwood. Two sets of sticks (14 x 14 x 200 mm, T x R x L, respectively) were used in this test. Fifty four samples were cut from two different boards (27 from each board). Prior to exposure in the decay test, the test specimens were soaked in deionized water for 48 hours, equilibrated in plastic bags for two days and then subjected to the Dynamic MOE measurement.

Soil and Decay Test Containers

A mixture of Dorman/Saucier soil and compost was used to make the soil substrate. The Dorman soil has a clay/loam texture and the Saucier soil has a sandy loam texture. These two soils were mixed at a volume ratio of 50/50. Then this Dorman/Saucier soil mixture was amended with compost at volume ratio of 75/25 (soil/compost). The compost was prepared by composting hardwood sawdust using 25% w/w chicken manure. The sawdust was allowed to decompose until the volume was reduced by approximately 50%.

Plastic boxes (87 mm wide, 87 mm long, and 64 mm high) were used as containers for the test. Two square holes were punched in two opposite side walls. An O-shaped ¼-inch-diameter plastic tube connected to an upright tube that extended up through the cover was embedded in each container. Seven holes were evenly punched in each O-shaped tube so that water added periodically would uniformly diffuse into the soil and keep the moisture of the soil at the desired level.

Ten randomly selected soil/compost mixture samples were oven dried to determine the soil mixture's MC. This MC was used to calculate the oven-dry weight of the soil/compost placed in each of the test boxes so that the MC could be determined for each container.

Soil Contact Decay Test

Two samples were inserted into each plastic box and soil was added to a level above the samples so they were imbedded in the soil/compost mixture. Then the soil/compost mixture was watered with de-ionized water to raise the MC to 20% w/w which provided conditions necessary to raise the MC of the wood samples to approximately 40%. Small wood samples (3 x 14 x 25mm) were wrapped in nylon hose material and inserted in some of the boxes to monitor the wood MC periodically. The boxes with the wood samples and soil/compost mixture were then stored in an incubator, where the temperature was maintained at 28 C with a humidity of approximately 50%. De-ionized water was added to the box every week to bring the MC of the soil/compost mixture to 20%. The wood MC samples were checked every week to make sure the wood sample MC was maintained between 40 – 80%.

Dynamic MOE test

The MOE was determined with a Grindo Sonic MK5i instrument. The samples were supported at 0.224 of their length from both ends with two soft plastic foam strips laid on a testing table provided by MK5i's manufacturer. A microphone was built into the testing table and the center of the wood sample was placed right above this microphone. Each sample was tapped with a rubber tapper in the middle of the sample. The tapper was a 5-mm diameter rubber ball attached to a 130-mm long, 1.5-mm diameter round wood stick. The samples were weighed immediately before their frequencies were measured. Sample MOE's were computed with the following formulae:

$$MOE_{dyn} = ((4 \times \pi^2 \times l^4 \times f^2 \times \rho \times A) / (m_1^4 \times I)) \times (1 + (I \times K_1)/(l^2 \times A)) \quad \text{[Eq. 1]}$$

Where:
I: moment of inertia [mm^4]
A: area of cross section [mm^2]
f: frequency [kHz]
ρ: density [kg/m^3]
l: length [mm]
K_1 = 49.48
M_1 = 4.72

After the initial evaluation the test samples were re-evaluated for MOE after 20, 50, 120, 170, and 230 days. The MC of all of the samples was above the fiber saturation point before they were tested.

Compression test

After being exposed to unsterilized soil for a total of 230 days, each sample stick was cut into twenty wafers (14 x 14 x 6 mm, T x R x L, respectively) using a band saw and numbered sequentially. The cutting scheme is illustrated in Figure 1. The wafers were saturated with de-ionized water by vacuum/soak (15 minutes vacuum at 78 mm Hg and 30 minutes soaking), before measuring their dimensions. The maximum compression strength at 5% strain level of each sample was measured on a custom-built testing apparatus with a loading speed of 12 mm/minutes.

RESULTS AND DISCUSSION

The average MOE of the test samples was reduced by 34.9% (Figure 2) after a total of 230 days of exposure. This represents a high rate of decay compared to normal field testing and is the result of closely controlled MC levels and the addition of composted wood to the soil substrate (Nicholas, et. al. 2004).

Data for the comparative compression strength test are shown in Figure 3, representing a typical distribution of compression strength losses along the length for all of the test samples after exposure for 230 days. In the accelerated soil contact decay test, only the middle sections of the wood samples were exposed while both ends remained unexposed. The average of the wafers cut from the unexposed portions was used as the sample's compression strength before exposure and the compression strength losses of the exposed portion were calculated by comparing the compression strengths of the wafers cut from the exposed sections against the unexposed compression strength. In the cutting scheme, the wafers numbered 1, 2, 3, 4, 17, 18, 19, and 20 represent the unexposed portions while the rest of the wafers represent the exposed sections. However, only wafer numbers 2, 3, 4, 17, 18, and 19 were used to calculate the unexposed compression strength because the wafer 1 and 20, cut from the very ends, always had minor defects such as checks which negatively affected the compression strength. The results showed that most samples suffered the highest compression strength losses close to their center and the compression strength losses gradually decreased as the wafers' positions moved towards the ends of the samples.

The average compression strength loss of the exposed section of each sample was calculated by averaging the compression strength losses of the wafers numbered 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15 and 16. The average compression strength losses of each sample were plotted against their dynamic MOE losses in Figure 4. A correlation of 0.884 was found between the average compression strength losses of the exposed section and the dynamic MOE losses for all of the test sticks in this study.

CONCLUSIONS

The results showed that the wood samples, with a cross section of 14 by 14 cm, have a relatively consistent distribution of decay within their soil contact sections when exposed to an accelerated soil contact wood decay test for 230 days. Two typical decay distributions were observed. Both distributions showed that the maximum decay was observed at a position close to the center of the exposed section. The difference between these two distributions was that one distribution had gradually decreased decay at locations towards the ends of the samples and the other distribution had a relatively consistent decay level within the exposed sections.

A correlation of 0.884 was observed between the average compression strength losses and the dynamic MOE losses after the samples were exposed for 230 days.

Figure 1. Cutting scheme for the 14mm square sticks used in the compression test.

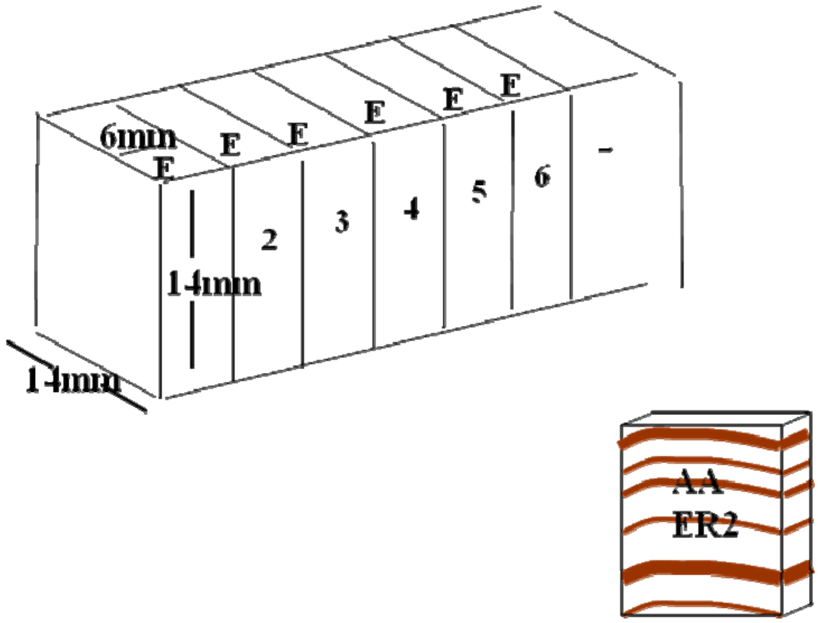


Figure 2. Average percent MOE loss for test samples after exposure to unsterile soil for 230 days.

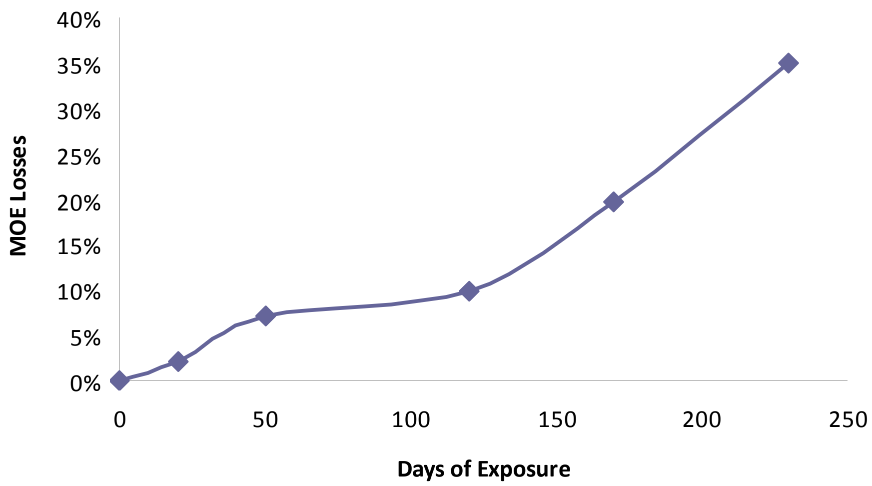


Figure 3. Two typical distributions of compression strength losses along the sample's longitudinal direction.

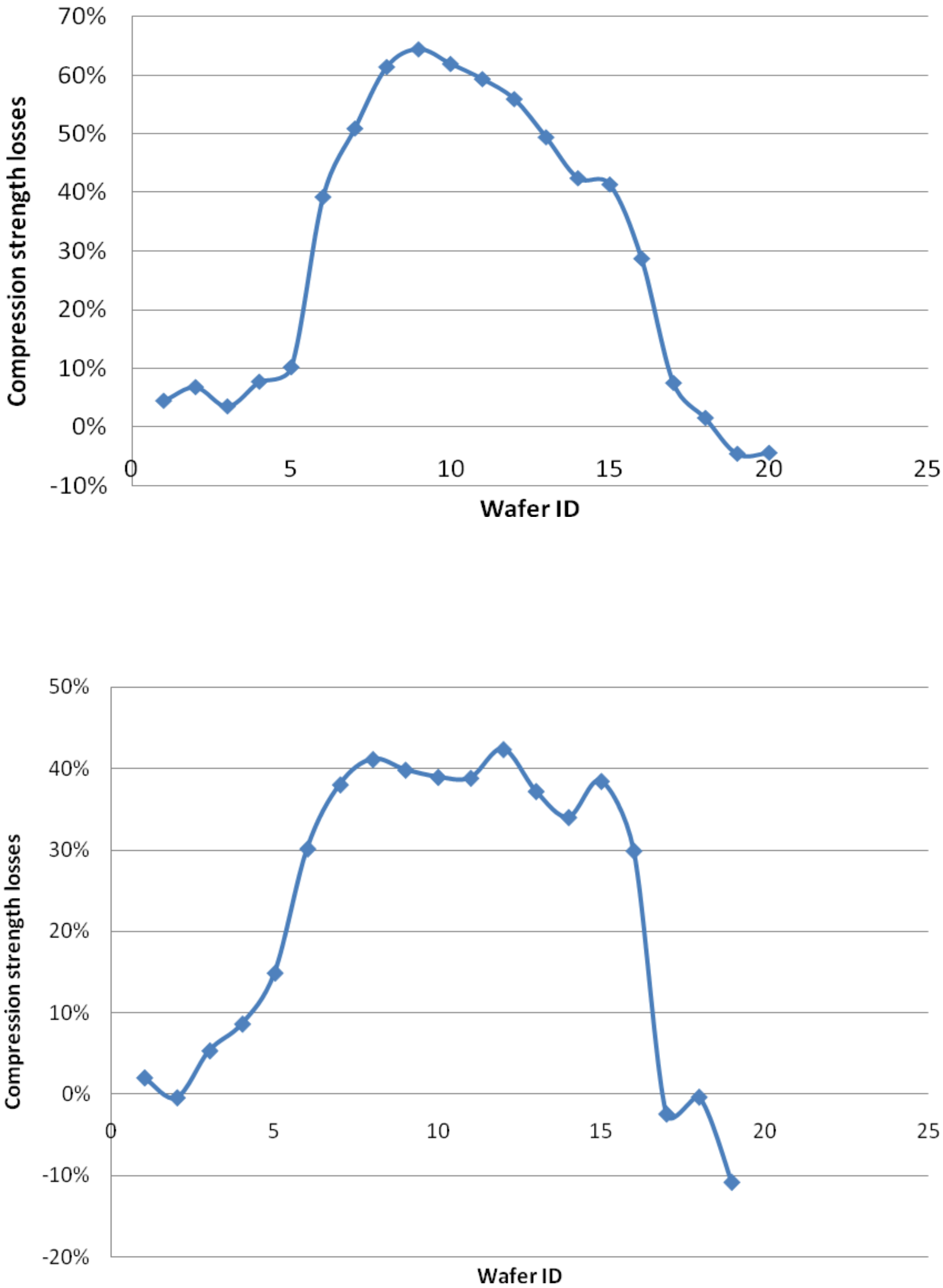
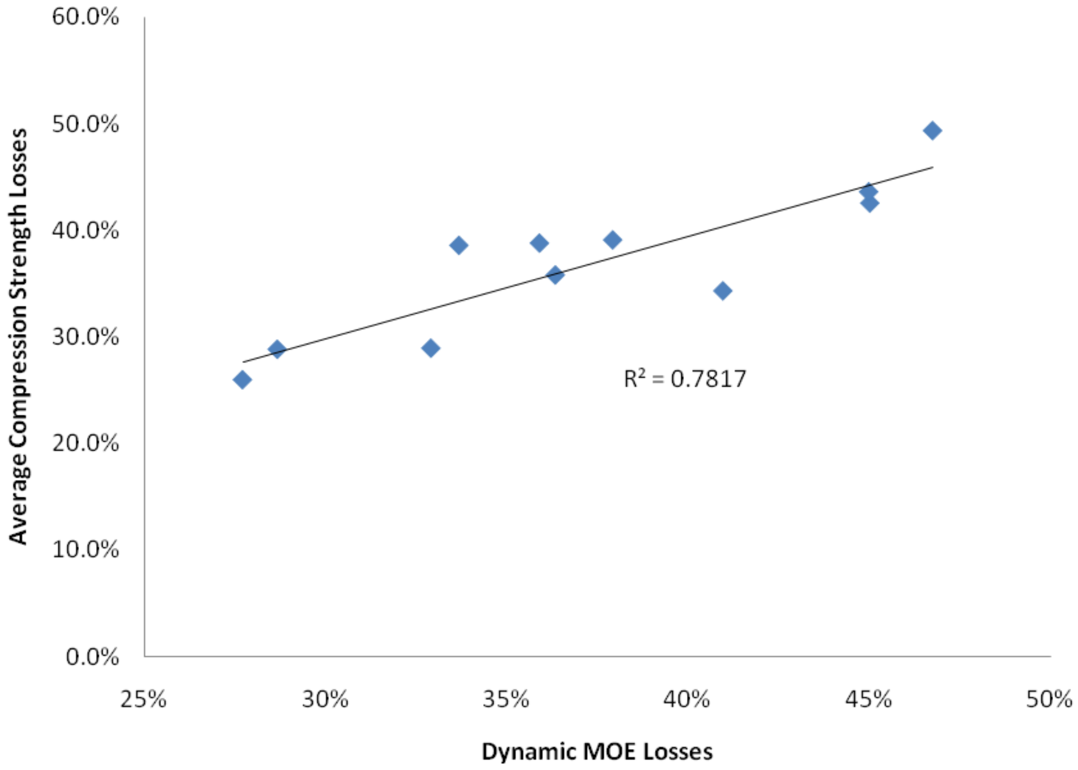


Figure 4. Comparison of average compression strength losses of the exposed portions to the dynamic MOE losses of the samples after 230 days of exposure.



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